

S-Band-X-Band Directional Coupler

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In support of an effort to reduce microwave noise bursts at the DSN tracking stations, an S-band-X-band directional coupler has been fabricated. The goal was to develop a directional coupler that has a coupling of about 30 dB using two different rectangular waveguide sizes.

I. Introduction

The DSN tracking stations have experienced occasional problems with excessive microwave noise bursts appearing in the low-noise receivers during high-power diplexing at S-band. Locating the source of such noise bursts has often proved to be quite difficult. The S-band-X-band directional coupler, shown in Figure 1, has been investigated as a possible aid in locating the source of the noise bursts.

It is assumed that the electrical breakdown that generates the noise burst has a broad band spectrum. The directional coupler couples the X-band component of the noise burst through WR 112 waveguide to a test receiver while, in effect, completely isolating the test receiver from the high-level S-band being transmitted in WR 430 waveguide. By inserting the directional coupler at various locations in the waveguide system, it should be possible to isolate the source of noise bursts to a particular component.

II. Design Considerations

With reference to Figure 2, the directional coupler consists of two unequal size rectangular waveguides

coupled together by means of a series of small coupling apertures on the broad walls between the two guides. The coupling theory is based on the diffraction of electromagnetic radiation by an aperture, where its size is small compared with the wave length. An incident wave in port 1 couples power into ports 3 and 4.

By proper adjustment of the aperture position d , the radiation in the direction of port 4 can be minimized and that in the direction of port 3 enhanced. The amplitude equations of the excited fields in the secondary waveguide are given in both References 1 and 2 in terms of its exciting and excited fields. In the case of a circular aperture, they are proportional to the cube of the radius. With the aid of a computer program the four amplitude equations have been solved for the proper aperture position d in order to obtain the maximum radiation into port 3 using a single-hole coupler model. The aperture position $d = 3.1750$ cm (1.25 inches) was chosen, and a circular aperture of radius $r_0 = 0.436563$ cm (0.171873 inches). Since the single-hole coupler model has a narrow bandwidth, many apertures were used in order to obtain better directivity over a larger bandwidth. There is a drawback in couplers using different sizes of coupling apertures because the ratio of the coupling coefficients is not constant over the frequency band. Thus, equal size

apertures were used, and equal spacing between the apertures was used for simplicity. Fifteen circular apertures were used, and the spacing between them, $D = 1.9320$ cm (0.80 inches) was chosen.

III. Tests

A waveguide coupler test sample has been fabricated. Low-power tests indicate that both good coupling and directivity were found over several bands of frequencies. Using a waveguide taper from X-band to S-band, it was possible to propagate an X-band signal inside the WR 430

waveguide of the coupler. With reference to Figure 2, the output of the excited waveguide (WR 112) was plotted on the X-Y plotter over a bandwidth as shown in Figure 3. Port 4 monitors the forward direction of the radiated power from port 1 and port 3 monitors the reverse direction of the radiated power from port 1. The directivity is obtained by subtracting one from the other.

With the test equipment available, a desirable frequency range would be the 8407-8417 MHz, which would afford about 30-dB coupling and 22-dB directivity over the 10-MHz bandwidth (Figure 3).

References

1. Montgomery, Dicke, and Purcell, "Principles of Microwave Circuits, " *Radiation Laboratory Series*, pp. 177-179.
2. R. E. Collin, *Foundations for Microwave Engineering*, McGraw-Hill Book Company, New York, 1966 pp. 190-197, pp. 270-282.

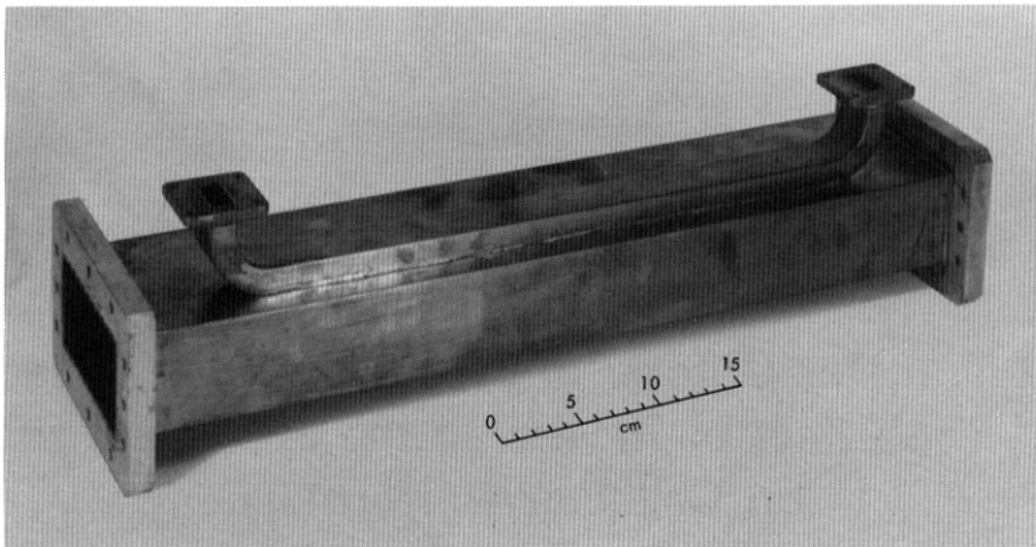


Fig. 1. S-band-X-band directional coupler

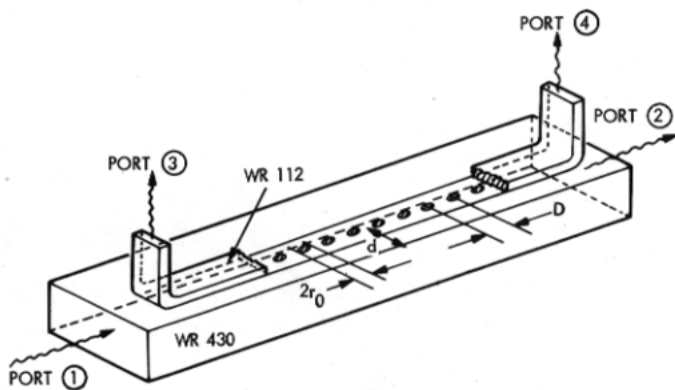


Fig. 2. Mechanical parameters

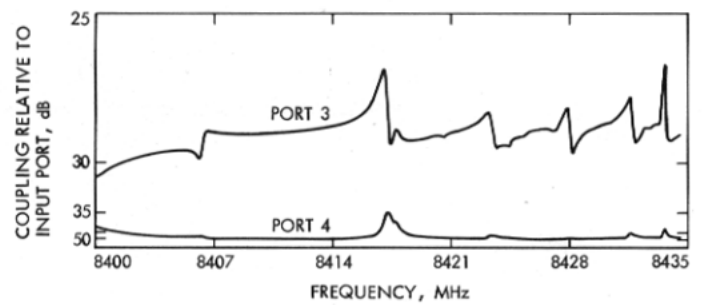


Fig. 3. Coupler performance